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The North American ASTER Land Surface Emissivity Database (NAALSED) v3.0

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Introduction

An accurate estimation of the Thermal Infrared (TIR) land surface emissivity is critical for deriving land surface temperatures from remote sensing satellites such as the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), a sensor on NASA's Terra satellite, part of the Earth Observing System (EOS), with 5 TIR bands in the 8-12 µm region and a 90 m spatial resolution. ASTER Land Surface Temperature and Emissivity (LST&E) products are currently produced on-demand and on a scene-by-scene basis. We have developed a method for producing mean, seasonal, gridded ASTER LST&E products. Given sufficient resources, this method could be used to produce a global gridded ASTER LST&E dataset that would be invaluable for a range of scientific studies that involve climate modeling, global climate change studies, land use and land cover change, and cryospheric research.

Background

ASTER has acquired enough data since launch in 2000 to produce global, gridded high spatial resolution (100 m) datasets. We have developed the methodology to compute a mean seasonal, gridded, Land Surface Temperature and Emissivity (LST&E) database at 100 m spatial resolution using all the ASTER scenes acquired for the months of Jan–Mar (winter) and Jul–Sep (summer) over North America. Version 2.0 of the North American ASTER Land Surface Database (NAALSED) (http://emissivity.jpl.nasa.gov) has now been released and includes two key refinements designed to improve the accuracy of emissivities over water bodies and account for the effects of fractional vegetation cover. In these seasonal datasets, the emissivity is calculated as the average emissivity of all clear-sky pixels for a given location, from all scenes acquired in the season over the entire period of acquisition of ASTER data (2000 - 2009).

Significance

Errors in emissivity of 0.1 (10 %) will result in Climate Models overestimating radiation budgets by up to 7 Wm². This represents a much larger term than the surface radiative forcing due to an increase in greenhouse gases (2-3 Wm²).

Atmospheric Retrieval Accuracy of temperature and moisture profiles from remote sounders such as Atmospheric Infrared Sounder (AIRS), are strongly dependent on an accurate estimation of the surface emissivity, particularly over arid and semi-arid regions.

Knowledge of the surface emissivity is critical in recovering the Land Surface Temperature (LST), an important climate variable in many scientific studies from climatology to hydrology and modeling the greenhouse effect.

	NAALSED v2.0	NAALSED v3.0
Temporal coverage	2000-2008	2000-2009
Cloud mask	v2.0 - Based on Landsat-7, MODIS and AVHRR cloud detection - Cirrus detection - Cloud/shadow discrimination	v3.0 - Improved snow/cloud thresholds - Elevation dependent brightness temperature thresholding - Updated cirrus test thresholds
Atmospheric Profiles	NCEP GDAS - Temporal interpolation - 100 km - TOMS ozone	MODIS MOD07 - Coincident - 5 km - MOD07 ozone
Atmospheric Correction	Standard Modtran 3.5	Water Vapor Scaling Modtran 5.0
TES algorithm	Standard TES plus fractional vegetation cover (FVC) correction	Standard TES

NAALSED Users/Applications

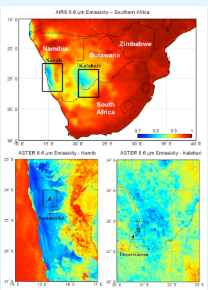
Arizona State University: NAALSED has been incorporated into JMARS (Java Mission-planning and Analysis for Remote Sensing) , a Java-based geospatial information system developed by ASU

UW-Madison: NAALSED is used for comparison with the MODIS baseline-fit surface emissivity product, a necessary product for retrieving MODIS atmospheric profiles (MOD07)

JPL: NAALSED has been used for evaluating the AIRS (Atmospheric Infrared Sounder) and IASI (Infrared Atmospheric Sounding Interferometer) land surface emissivity products

JPL: The Tropospheric Emission Spectrometer (TES) group will be using NAALSED as a first guess emissivity in their retrieval algorithm for Ozone

AIRS Land Surface Emissivity Validation



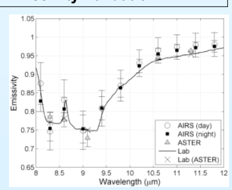
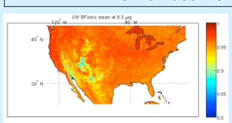


Figure 2. AIRS mean emissivity image at 8.6 µm and corresponding ASTER emissivities for the Namib and Kalahari desert validation areas (left). Emissivity spectra comparisons between AIRS, ASTER and Lab results for the Namib desert. (top)

MODIS Baseline-fit Comparisons



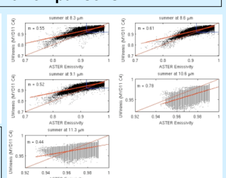


Figure 3. MODIS baseline fit emissivity image at 8.3 µm (top), and scatterplots of NAALSED v2.0 and MODIS BF emissivity for four wavelengths in the TIR (right).

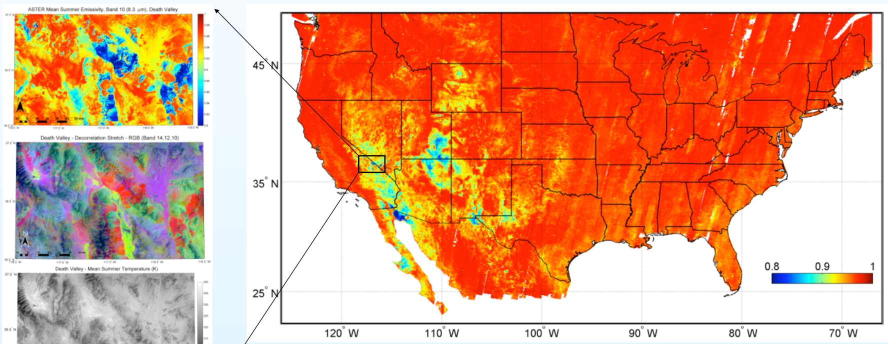


Figure 1. The North American ASTER Land Surface Emissivity Database (NAALSED) Band 12 (9.1 µm) mean summertime emissivity using 52,424 ASTER scenes from 2000-2009. White areas over land had no clear-sky coverage during the acquisition period. Images at left show the emissivity (top), decorrelation stretch (middle) and surface temperature (bottom) over Death Valley.

Summary

- **A mean, seasonal, gridded ASTER Land Surface Emissivity Database has been developed at high spatial resolution (100m).**
- **NAALSED data is less noisy than standard ASTER products, with the result that decorrelation stretches (Fig. 4) are much smoother and easier to interpret, and have applications for mineral mapping.**
- **Seasonal emissivity differences (winter minus summer), indicate the greatest variability occurs in areas affected by snow (Sierra Nevadas), and agricultural regions (Central Valley in CA).**
- **NAALSED will be invaluable for climate modeling groups and the atmospheric retrieval community, who will not only get an estimate of the mean seasonal emissivity, but also how much range is expected in that emissivity before it becomes unrealistic.**
- **NAALSED emissivities have been validated to within 0.016 (1.6%) over 9 sand dune sites with a wide range in emissivity in the TIR.**

References

1. Hulley, G. C., S. J. Hook, and A. M. Baldridge, (2009), Validation of the North American ASTER Land Surface Emissivity Database (NAALSED) version 2.0 using pseudo-invariant sand dune sites, *Remote Sens. Environ, 113*, 2224-2233
2. Hulley, G. C., and S. J. Hook (2009), The North American ASTER Land Surface Emissivity Database (NAALSED) Version 2.0, *Remote Sens. Environ, 113*, 1967-1975
3. Hulley, G. C., S. J. Hook, E. Manning, S-Y Lee, and E. Fetzer, (2009), Validation of the Atmospheric Infrared Sounder (AIRS) Version 5 Land Surface Emissivity Product over the Namib and Kalahari Deserts, Journal of Geophys. Res. Atmos., in press
4. Hulley, G., S. J. Hook, (2008), ASTER Land Surface Emissivity Database of California and Nevada, Geophys. Res. Lett., 35, L13401, doi:10.1029/2008GL034507
5. Hulley, G., S. J. Hook, (2008), A New Methodology for Cloud Detection and Classification with Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Data, Geophys. Res. Lett., 35, L16812, doi:10.1029/2008GL034664

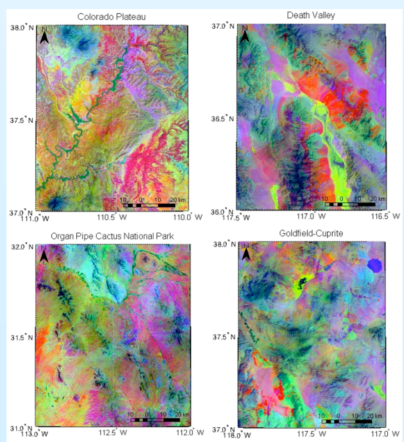


Figure 4. NAALSED decorrelation stretch images over four different regions. Red, green and purple represent quartz-rich rocks, carbonates, and quartz-poor rocks respectively.

Emissivity Validation

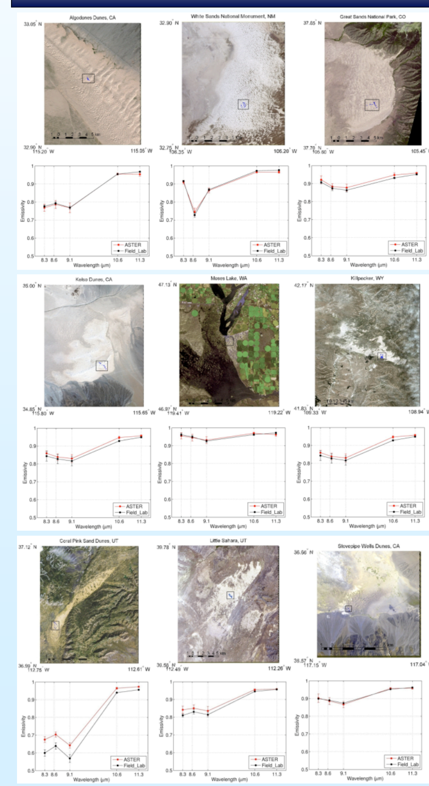


Figure 5. ASTER visible images and emissivity spectra comparisons between NAALSED and lab measurements of sand samples from nine pseudo-invariant sand dune sites over the southwestern USA. Rectangles with blue dots in visible image indicate sampling areas

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